

AD-A107 660

CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL F/G 5/1
EXPECTED USE OF MICRO-BASED NETWORK ANALYSIS. (U)

NOV 81 C E DELONG, J H SPOONAMORE

UNCLASSIFIED

CERL-TM-P-122

NL

1 OF 1
AD A
107660

END
DATE
FILMED
1-82
DTIC

✓
construction
engineering
research
laboratory



United States Army
Corps of Engineers
*Serving the Army
Serving the Nation*

12

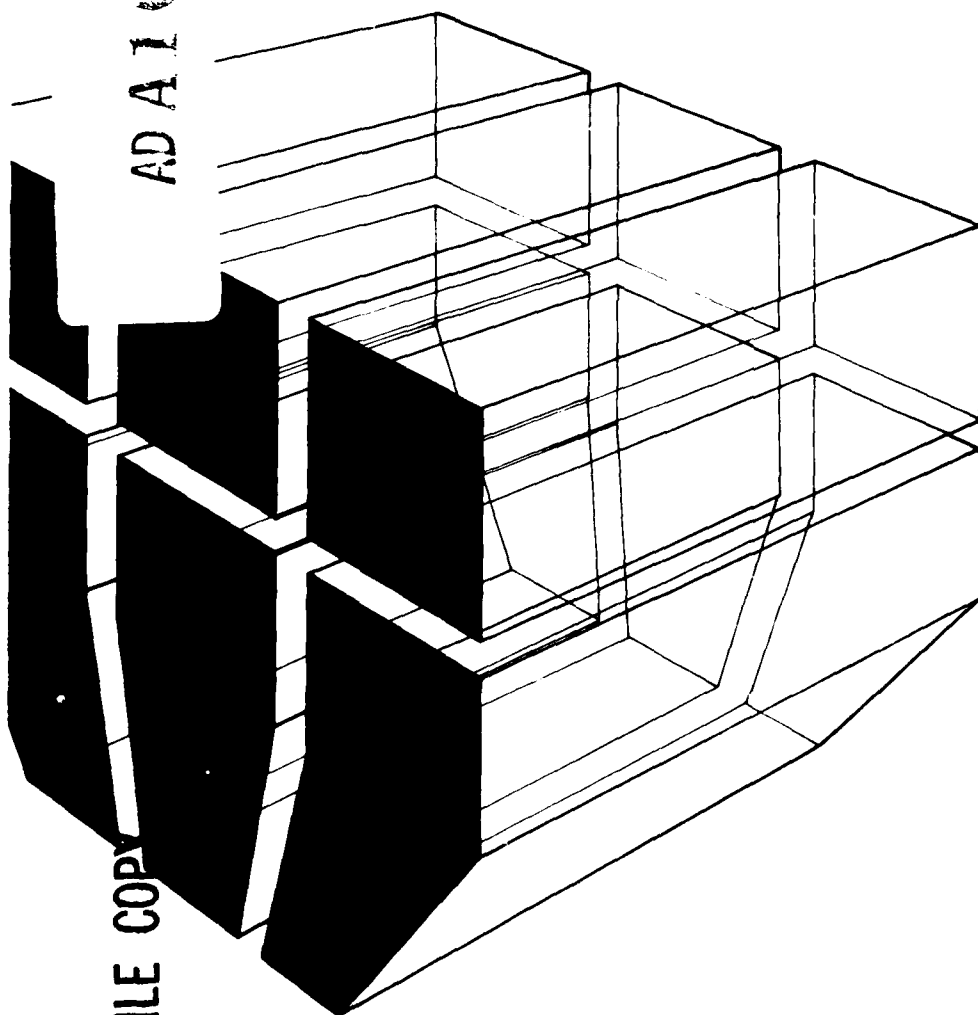
LEVEL II

TECHNICAL MANUSCRIPT P-122
November 1981

EXPECTED USE OF MICRO-BASED
NETWORK ANALYSIS



by
Carl E. Delong
Janet H. Spoonamore



DTIC FILE COPY

AD A101 630



The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official indorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

**DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED
DO NOT RETURN IT TO THE ORIGINATOR**

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CERL-TM-P-122	2. GOVT ACCESSION NO. AD-A107 666	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EXPECTED USE OF MICRO-BASED NETWORK ANALYSIS		5. TYPE OF REPORT & PERIOD COVERED FINAL MANUSCRIPT
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Carl E. DeLong Janet H. Spoonamore		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005, Champaign, IL 61820		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE November 1981
		13. NUMBER OF PAGES 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Copies are obtainable from the National Technical Information Service Springfield, VA 22151		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) microcomputers network analysis (management) construction		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Over the next decade, engineers have an excellent opportunity to use available low-cost, micro-based hardware. Network analysis is a suitable software tool for managing small and large, simple and complex project networks even on the small machines. One may ask whether and how engineers will use micro-based network analysis given its limited use in the past. Data on the current construction projects indicate that engineers will not quickly and easily adapt these micro-based tools. The same data also suggest that		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Block 20 continued.

established users will more and more depend on their micro computers.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

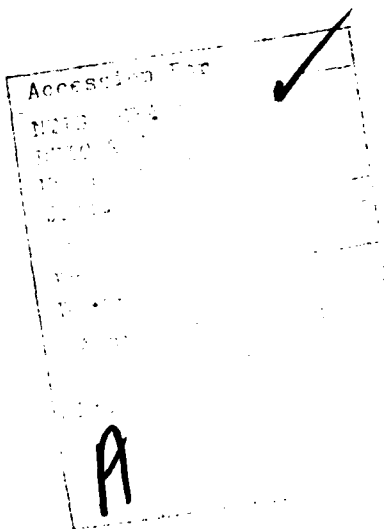
FOREWORD

This manuscript was presented at the First International Computer Conference in Civil Engineering, New York, 12 May 1981.

The work was performed for the Directorate of Military Programs, Office of the Chief of Engineers, under Project 4A762731AT41, "Design and Construction of Fixed Military Facilities"; Task A, "Design and Construction"; Work Unit 35, "Microprocessor Applications to the MC Process." The applicable QCR is 303.006. The OCE Technical Monitor was Mr. Phil Pinol.

The research was conducted at the U.S. Army Construction Engineering Research Laboratory (CERL) by the Facility Systems (FS) Division. Mr. Edward Lotz is Chief of FS.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.



ABSTRACT

Expected Use of Micro-Based Network Analysis

by

Carl E. DeLong
Janet H. Spoonamore

Over the next decade, engineers have an excellent opportunity to use available low-cost, micro-based hardware. Network analysis is a suitable software tool for managing small and large, simple and complex project networks even on the small machines. One may ask whether and how engineers will use micro-based network analysis given its limited use in the past. Data on the current construction projects indicate that engineers will not quickly and easily adapt these micro-based tools. The same data also suggest that established users will more and more depend on their micro computers.

Vita

Ms. Janet Spoonamore has been an operations researcher with the Corps of Engineers, Construction Engineering Research Laboratory, Champaign, Illinois, since 1973. She has designed and developed micro-based tools for use in construction management and architectural design. Prior to her Corps research, Ms. Spoonamore developed parallel numerical methods and econometric models at the University of Illinois Center for Advanced Computation.

Mr. Carl DeLong has been with the Corps of Engineers since 1969. After three years of civil works field construction experience, he served as an office engineer in a military construction area office. In 1972, he transferred to CERL, where he has developed computer-based construction management techniques. In addition, he has been heavily involved in the functional analysis of Corps of Engineers organizations. Prior to his Corps employment, he worked for the Bureau of Public Roads and the U.S. Geological Survey. Mr. DeLong is currently president of the Central Illinois Section, ASCE.

Expected Use of Micro-Based Network Analysis

Background

The development of microprocessors during the 1970's and the resulting decrease in computational costs made it feasible to consider putting microcomputers in Corps field offices. By the end of the 1970's a complete microcomputer system had become desk size. These computer systems include a CRT terminal, a medium speed line printer, and a dual drive, floppy disk system. Further refinements to this technology allowed hard disks to be attached, thereby allowing a full range of computing power to field offices. This development offers opportunities to the Corps of Engineers, a widely dispersed construction agency.

Construction field office major roles include administering, monitoring, and managing the construction process. These offices are small, widely dispersed and transient in nature. Large-scale, automated procedures are not appropriate for use in these environments as is evidenced by the lack of such tools. Considerable attention has focused on network analysis as the ideal tool for use in managing construction projects. It provides the ability to immediately evaluate large projects using automated tools.

Objective

The RDT&E work unit "Microprocessor Applications to the Military Construction Process" is a research effort conducted at the U.S. Army Construction Engineering Research Laboratory (CERL).

CERL's purpose is to research and test the feasibility of microprocessor applications to the military construction process. The MICRO project will identify, evaluate, and implement tools on micro-based equipment to support construction field office operations. The major effort is to develop applications having high benefits to construction management and to prepare specifications and guidance for implementing these applications.

DESCRIPTION OF RESEARCH PROJECT

Initial steps included an analysis of potential field applications. An economic analysis of each application was prepared and the application ranked according to the potential high cost benefits.

A microcomputer system was procured and a critical path method (CPM) program was implemented on the microcomputer system. This CPM software package was designed to aid Corps of Engineers field officers in the administration of construction contracts for military facilities. The development of this system, which was reported at the October 1978 ASCE Convention in Chicago, proved the feasibility of

comprehensive software packages for the Corps of Engineers on micro-computer equipment.

Concurrent research was conducted in the area of modification analysis. Techniques for impact analysis require network analysis and thus require the availability of this microcomputer tool. Network analysis identifies the impacts of modifications both in terms of project timing and individual activity changes. This work has become a Corps of Engineers manual on impact analysis.

Field Tests

After development of the CPM-based software, field tests were conducted to provide an analysis of our concepts. Basic concepts included (1) a non-ADP oriented user system, (2) a microcomputer system capable of handling a comprehensive project management software package, (3) hardware capable of operating in an uncontrolled environment.

The first field test answered several concept questions as follows:

1. It is feasible to do comprehensive programming on microprocessor-based equipment. Specifically, it is feasible to implement a network analysis program handling up to 1200 activities in core, although it taxes the resources of the printer and floppy disk.
2. It is feasible for non-computer trained personnel to operate micro-based equipment if it is based on "user-friendly design" concepts.
3. A special environment for computer equipment is not necessary.
4. The staff involved with construction management must be committed to analytical practices for a computer tool offering analysis to be of benefit.

CERL is currently conducting another field test with commercial equipment and software. This will enable CERL to develop hardware and software specifications and ADP documentation required to implement microcomputers in field offices.

Both of these tests involve managing large construction projects. The users of the system are not professional ADP staff. The training for both tests was performed in less than one week with the user manually loading the initial networks.

The field test is as follows: A permanent copy of all official changes is made. The network is regularly updated to reflect progress and changes. These modifications must be evaluated quickly and the updated network provides a tool for modification analysis.

Trends in Network Analysis Usage

Based on analysis of the information gathered from Corps CPM usage, those who use network analysis tend to rely more and more on it for project control and analysis. However, only a small percentage of area offices use this technique.

Tables 1 through 4 provide a profile of CPM usage.

The data in these tables indicate use of network analysis for project management is limited. This sample of corps offices may not reflect the total Corps picture nor construction in general. However, in reviewing those offices using network analysis, it is clear that:

1. Project size (number of activities) is not a factor.
2. Project cost is not a factor.
3. Office size is not a factor.

Further, it appears that offices using network analysis must have the capacity to analyze projects as large as 2000 activities. What this suggests is the need for micro-based network analysis to handle large networks.

Projected Hardware Usage

User-friendly software has drawn favorable comment from the field tests. Basic input to the program can be accomplished by non-technical personnel as the program is menu-driven and data input is inserted to a formattable screen with a movable screen cursor.

The size of the equipment is adequate to handle 90 percent of networking projects. Removable memory storage allows flexibility in user requirements so that the user does not see size limitations.

The user sees a considerable printing time with large sized networks. Consequently, it is necessary to provide a medium to high speed printer or have selective print capability with the software program.

The equipment and software has been used to evaluate modification and project impacts before the fact. It has proven to be a powerful tool in negotiating for two reasons. First, the client can be informed of the cost and time impacts. Based on this information, the client may decline to issue a requested modification. Second, the contractor's proposal for incorporating the modification can be evaluated against several alternatives.

Table 1

Field Office Placement (FY79)

District	No. Field Offices per District	Total Military Placement per District (millions \$)	Avg. Military Placement per Field Office (millions \$)	Total No. Staff per District	Avg. No. Staff per Field Office	Avg. \$ per Staff (millions \$ per Staff)
Fort Worth	6	182.3	30.4	218.0	36.3	.84
Kansas City	3	36.7	12.2	27.0	9.0	1.36
Mobile	17	185.5	10.9	177.0	10.4	1.05
New York	4	50.2	12.6	46.0	11.5	1.09
Norfolk	3	45.0	15.0	46.0	15.3	.98
Omaha	7	87.4	12.5	94.0	13.4	.93
Sacramento	4	74.3	18.6	80.0	20.0	.93
Savannah	9	83.3	9.3	95.0	10.6	.88

Total	53	744.7		783		
Avg.		14.1		14.8	.95	

Table 2
Representative Projects Having CPM's
(Summer 1980)

District	Field* Office	Total Number Projects in Office	Number	CPM Projects Average per CPM Project		
				Acts	\$ Val (1,000,000)	Duration (days)
5	A	11	9	515	\$3.1	665
	B	12	1	495	\$2.6	734
2	C	7	4	3300	\$14.0	
6	D	17	3	715	\$10.0	952
	E	37	2	1016	\$13.0	720
3	F	12	4	3779	\$14.5	
	G	10	4	1000	\$4.7	
1	H	7	2	650	\$15.	
	I	13	3	1500	\$20.	
8	J	30	9	570	\$14.	
	K	11	6	787	\$5.3	
	L	16	11	1290	\$3.25	
	M	9	7	511	\$2.7	
	N	23	11	583	\$5.7	
Totals	14 offices	214	76	81455	\$584.0	
Averages (weighted)				1072	\$7.7	734

Average of \$7200/Activity

*Asked for the largest field offices in the District.

Table 3
Profile of Project

CPM/Man CPM	
avg. # acts/project	1072
avg. \$ value/project	\$7.7 million
avg. duration/project	734 days
avg. \$ value/activity	\$7200
avg. duration/activity	1 month
avg. \$ value/modification	\$19,250*
avg. frequency of modifications	once/month

*Based on 6% contingency: 734 days 24 months

$$\text{mod} = \frac{\text{cost}}{24 \text{ mo.}} = \frac{.06 \times \$7,700,000}{24 \text{ mo.}} = \$19,250$$

Table 4
Individual CPM Projects*
(Summer 1980)

District	Field Office	No. Activities	Total \$ Val (1,000,000)
5	A	495	2.6
2	C	2750	13.0
		5014	16.6
6	D	600	12.0
		800	12.0
		750	8.2
	E	1279	20.1
		754	7.6
3	F	9426	36.0
		706	6.0
		1205	1.5
	H	300	3.6
		1000	27.0
1	I	1000	3.3
		2000	36.0
	J	200	27.0
		2000	35.0
		250	.65
		200	4.7
		200	2.4
8	K	969	5.6
		418	2.6
		877	1.8
		887	3.0
	L	1764	4.9
		445	6.0
		4990	18.4
		450	3.1
		469	1.9
		679	6.7
		2644	2.5
		782	4.8
		106	.79
		574	1.6
	M	879	8.1
		202	2.0
		236	1.2
		1248	4.0
		647	1.8
		215	1.7
		156	.97
	N	1655	1.4
		984	7.2
		213	.73
		489	2.6
		292	.96
		480	7.6
		284	2.1
		283	.64

Projects with < 2000 activities: 44; % of total = $\frac{44}{49} = .90$

Projects with > 2000 activities: 5; % of total = $\frac{5}{49} = .10$

* Only listed those projects having data available on Number of Activities per individual project.

Processing

Table 5 shows the projected processing requirements for network analysis systems based on the field test usage. Requirements for processing are determined by computations for: (a) performing the network analysis, (b) updating onto the disk, and (c) presenting the network results. Current equipment timing is used in deriving the processing times. A microsystem based on floppy disks is clearly unacceptable for expected usages.

Table 5
Monthly Progress Update

		1,000 Nodes	10,000 Nodes	10 Projects @ 5,000 Nodes
CPM	HARD DISK	4m	48m	4h
	Floppy Disk	75m	16h	77h
SAVE	HARD DISK	1m	10m	50m
	Floppy disk	10m	100m	8h
	BYTES storage	84k	840k	4M
PRINT	Time	10m	100m	8h
	Pages	40	400	2000
Total	HARD DISK			13h
	Floppy Disk			93h

m = minutes, h = hours, k = kilo, M = mega.

Hardware

The final system specifications have not been field determined. Based on provisional specifications, the following criteria have been developed.

a. The equipment should be desk size with a main processor having 16-bit registers with a direct memory access channel. It should include four serial and two parallel I/O ports and have a memory management controller and floating point processor. Basic core memory should be at least 64 K bytes. There should be an option to install a mass storage controller.

b. At a minimum, there should be a two-disk drive with a minimum of five megabytes high speed capacity.

c. All field equipment should include a power supply of 115-volts, 4-amp switching supply with a line filter and monitor for orderly shutdown.

d. Peripherals should include an interactive CRT terminal of 80 characters; a medium to high speed line printer (150 lines per minute) capable of printing 132 characters with form feed and bottom feed should have at least a 96-character ASCII set. The system should have a communications port capable of accepting an RS-232 modem for usage as an intelligent terminal.

Software

Software should include a project management package. It should be user-oriented and menu-driven. Input should be to either a fixed format or to a line input of specific information. The system should include an operating system to support higher level languages such as standard FORTRAN or PASCAL.

Utilities should include a text processing subsystem which is line-oriented and a Data Based management system with user defined files. In addition a sort/merge package and a MATH package should be made available.

The project management system should be configured to handle the features as shown in Table 6, CPM/Networking Features Matrix. The table shows the Networking attributes for Micro Based Systems and Large-Scale Time Sharing Systems. The essential characteristics for a microbased network analysis system include summary reporting and medium to large network handling, ideally 2000 activities or more. These features are not found on all systems.

Maintenance

Based on our field tests, the vendor of the hardware and software should provide a maintenance service. The following criteria are necessary.

a. Telephonic consultation for all problems available on a daily basis with a specifically designated project individual.

b. A three-day response time in repair of hardware and software items.

Table 6

CPM/Networking Features Matrix

Features	A Micro Based Requirement	B Time-Sharing
General		
Projects	1	Projects linked
Activities/project	2000	10,000
Relationships/Activity	20	100
Relationships/Network	6000	30,000
Network Scheduling Technique		
i,j/precedence	Both	both
Activity Identification	5	9 characters
Activity Description	20	45 characters
Calendar	5, 6, 7	5, 6, 7 day multiple within project
Time Segments	Hours, days, weeks	Hours, days, weeks
Error Override	No	Yes
Input Format	Menu, fixed format	Fixed & Free
Input Edit	Yes, selective listing of data	Verification of data
Input Feasibility		
	Code and logical checks	Code and Logical checks
Open Ends Detection	No	Yes
Loop detection	Yes	Yes
Automatic File Maintenance	Yes	Yes
Resourcing		
Resource edit	Yes	Yes
Availability Profile	Summary lists	Graphical and summary
Resource requirements	Linear, lump	Linear, lump, complex
Utilization/Resource type	Summary list	Graphical and summary
Resources/Activity	6	10
Resources/Network	30	30
Activity		
Resource Summary Reporting	Yes	Yes
Resource Scheduling Options	No	Time and resource constraints
Resource Constraints	No	Priority and ranking rules

Table 6 (cont'd)

Target Schedules		
Target Network	Backup	Backup copies
Comparative Reportign	Barcharts, exceptions, and summary listing	Barchart, summary and exception listing
Multiproject Scheduling	No	Yes
Network Interfaces	No	Interrelated and stand-alone
Output		
Report Writer	Yes, flexible	Yes, flexible
Sorting	6 characters	12 characters
Selecting	Chronological on most fields	Chronological all fields
Windowing	Listed and graphical reports	Listed and graphical reports
Summary	Barcharts, listings	Barcharts, continuous and non-continous listings
Hammock	Yes	Yes
Network generator	No	Generates network from frag-nets
Float calculations	Total, scheduled, free	Specified float
Graphical Output (plotter)	No	Yes
Required Personnel	Clerk/typist input	Experienced personnel

Training

Before installation pretraining is required. Pretraining should include, at a minimum, one week of concepts and one week of hands-on experience before installation of the hardware and software.

Other Applications

Given the opportunity to process data, other applications besides network analysis can easily be supported on the same equipment. Table 7 shows the highest potential functions for computerized field office management.

Development of applications such as cost-accounting and personnel should be based on current Data Base Management Systems (DBMS). These systems allow the user to develop in-house data files for specific purposes. Data Base Management Systems allow the users to develop their specific needs and negate the need for a series of specialized software programs in the areas such as shop drawing registers, modification registers, and files for cost estimating purposes.

Additionally, a field computer enables a word processing system to be available for office administration purposes. Both the Data Base Management system and Word Processing system are low-cost and user-oriented. They require minimal training and address the functions of contract administration and office management.

Conclusions

Low-cost microcomputer equipment can be used for network analysis in the following areas:

1. Project control
2. Modification analysis before the fact.
3. Impact analysis before the fact.
4. As a tool to provide information for negotiating.

The ability to generate hard copy data provides a significant tool for the field office. User comments indicate that a significant advance has been made in providing field office support based on this capability. Network analysis techniques have been used to evaluate project logic concepts.

Effective implementation of microcomputers in field offices depends upon existing management philosophy. The basis for project management revolves around the concept of networking. If the manager uses a non-analytic approach, implementation of micro-based computer systems will not be completely successful. However, if the manager

Table 7

Potentials for Computerized Field Office Management

Construction Management

Project CPM (IJ or Precedence)
Construction Schedule Monitoring
Progress Reporting
Change Order Management
Cost Estimating Database
Workload Forecasting

Office Administration

Word Processing
Personnel files and listings
Equipment schedule and utilization
Time and attendance
Office Management Systems
Files Management

Contract Administration

Partial Payments
Fiscal Status & Reports
Submittal Management
 Submittal Register
 Submittal Status
Technical Reference material
Installed Real Property

is data-oriented and uses data in the decision-making process, it will be feasible to introduce micro-based computing systems.

Current commercial costs for acceptable hardware configurations vary between \$6,000 and \$20,000 for microcomputer equipment based on Table 5. Software costs vary between \$8,000 and \$20,000. The total range including Data Based Management system and a Word Processing system is between \$10,000 and \$45,000. Presently, there are two successful project management large-scale mini-computer systems in the \$125,000 to \$150,000 range. However, this is a very volatile area and the potential user can anticipate significant changes in hardware and software costs on a yearly basis.

By implementing microcomputer equipment our field tests have shown that:

1. Extra personnel are not required in field offices.
2. Non-technical personnel can be utilized if the software is "user-friendly" and menu-driven.
3. Considerable before-the-fact information can be provided to the decision-maker.

CERL DISTRIBUTION

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-ASI-L (2)
ATTN: DAEN-CCP
ATTN: DAEN-CW
ATTN: DAEN-CWE
ATTN: DAEN-CWM-R
ATTN: DAEN-CWO
ATTN: DAEN-CWP
ATTN: DAEN-MP
ATTN: DAEN-MPC
ATTN: DAEN-MPE
ATTN: DAEN-MPO
ATTN: DAEN-MPR-A
ATTN: DAEN-RD
ATTN: DAEN-RDC
ATTN: DAEN-RDM
ATTN: DAEN-RM
ATTN: DAEN-ZC
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM

US Army Engineer Districts

ATTN: Library
Alaska
Al Batin
Albuquerque
Baltimore
Buffalo
Charleston
Chicago
Detroit
Far East
Fort Worth
Galveston
Huntington
Jacksonville
Japan
Kansas City
Little Rock
Los Angeles
Louisville
Memphis
Mobile
Nashville
New Orleans
New York
Norfolk
Omaha
Philadelphia
Pittsburgh
Portland
Riyadh
Rock Island
Sacramento
San Francisco
Savannah
Seattle
St. Louis
St. Paul
Tulsa
Vicksburg
Walla Walla
Wilmington

US Army Engineer Divisions

ATTN: Library
Europe
Huntsville
Lower Mississippi Valley
Middle East
Middle East (Rear)
Missouri River
New England
North Atlantic
North Central
North Pacific
Ohio River
Pacific Ocean
South Atlantic
South Pacific
Southwestern

Waterways Experiment Station

ATTN: Library

Cold Regions Research Engineering Lab

ATTN: Library

US Government Printing Office

Receiving Section/Depository Copies (2)

Defense Technical Information Center

ATTN: DDA (12)

Engineering Societies Library

New York, NY

FESA, ATTN: Library

ETL, ATTN: Library

Engr. Studies Center, ATTN: Library

Inst. for Water Res., ATTN: Library

SHAPE

ATTN: Survivability Section, CCH-OPS
Infrastructure Branch, LANDA

HQ USEUCOM

ATTN: ECJ 4//-L01

Army Instl. and Major Activities (CONUS)

DARCOM - Dir., Inst., & Svcs.

ATTN: Facilities Engineer

ARRADCOM

Aberdeen Proving Ground
Army Matls. and Mechanics Res. Ctr.
Corpus Christi Army Depot
Harry Diamond Laboratories
Dugway Proving Ground
Jefferson Proving Ground
Fort Monmouth
Letterkenny Army Depot
Natick Research and Dev. Ctr.
New Cumberland Army Depot
Pueblo Army Depot
Red River Army Depot
Redstone Arsenal
Rock Island Arsenal
Savanna Army Depot
Sharpe Army Depot
Seneca Army Depot
Tobyhanna Army Depot
Tooele Army Depot
Watervliet Arsenal
Yuma Proving Ground
White Sands Missile Range

FORSCOM

FORSCOM Engineer, ATTN: AFEN-FE

ATTN: Facilities Engineers

Fort Buchanan
Fort Bragg
Fort Campbell
Fort Carson
Fort Devens
Fort Drum
Fort Hood
Fort Indianatown Gap
Fort Irwin
Fort Sam Houston
Fort Lewis
Fort McCoy
Fort McPherson
Fort George G. Meade
Fort Ord
Fort Polk
Fort Richardson
Fort Riley
Presidio of San Francisco
Fort Sheridan
Fort Stewart
Fort Wainwright
Vancouver Bks.

TRADOC

HQ, TRADOC, ATTN: ATIN-FE

ATTN: Facilities Engineer

Fort Belvoir
Fort Benning
Fort Bliss
Carlisle Barracks
Fort Chaffee
Fort Dix
Fort Eustis
Fort Gordon
Fort Hamilton
Fort Benjamin Harrison
Fort Jackson
Fort Knox
Fort Leavenworth
Fort Lee
Fort McClellan
Fort Monroe
Fort Rucker
Fort Sill
Fort Leonard Wood

INSCOM - Ch. Instl. Div.

ATTN: Facilities Engineer

Vint Hill Farms Station
Arlington Hall Station

WESTCOM

ATTN: Facilities Engineer

Fort Shafter

MDW

ATTN: Facilities Engineer

Cameron Station
Fort Lesley J. McNair
Fort Myer

HSE

HQ USAF, ATTN: DSC-1
ATTN: Facilities Engineer
Fitzsimons Army Medical Center
Walter Reed Army Medical Center

USACE

ATTN: Facilities Engineer
Fort Huachuca
Fort Ritchie

MTMC

HQ, ATTN: MTMC-1A
ATTN: Facilities Engineer
Oakland Army Base
Bayonne MCI
Sunny Point MCI

US Military Academy

ATTN: Facilities Engineer
ATTN: Dept. of Geography
Computer Science
ATTN: USIFER/MAEN-A

USAES, Fort Belvoir, VA

ATTN: ATZA-DTE-1A
ATTN: ATZA-DTE-1B
ATTN: ATZA-FE
ATTN: Engr. Library

Chief Inst. Div., ARPA, Rock Island, IL

USA ARRCOM, ATTN: Dir., Inst. & Svcs.

TARCOM, Fac. Div.

TECOM, ATTN: DTE-1A, 1B, 1C

TSARCOM, ATTN: DTE-1A, 1B, 1C

NARAD COM, ATTN: DTE-1A, 1B, 1C

AMMRE, ATTN: DTXMR-WI

HQ, XVIII Airborne Corps, Ft. Bragg

ATTN: AFZA-FE-EE

HQ, 7th Army Training Command, ATTN: AETG-DTE-1A

HQ USAREUR and 7th Army, ODCS/Engineer, ATTN: AEEN-EE (2)

V Corps, ATTN: AETVDEH (2)

VII Corps, ATTN: AETSDEH (4)

21st Support Command, ATTN: AEREH (4)

US Army Berlin, ATTN: AERA-EN (2)

US Army Southern European Task Force, ATTN: AISE-ENG (4)

US Army Installation Support Activity, Europe, ATTN: AEIES-PP

8th USA, Korea, ATTN: EAFE

1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22nd, 23rd, 24th, 25th, 26th, 27th, 28th, 29th, 30th, 31st, 32nd, 33rd, 34th, 35th, 36th, 37th, 38th, 39th, 40th, 41st, 42nd, 43rd, 44th, 45th, 46th, 47th, 48th, 49th, 50th, 51st, 52nd, 53rd, 54th, 55th, 56th, 57th, 58th, 59th, 60th, 61st, 62nd, 63rd, 64th, 65th, 66th, 67th, 68th, 69th, 70th, 71st, 72nd, 73rd, 74th, 75th, 76th, 77th, 78th, 79th, 80th, 81st, 82nd, 83rd, 84th, 85th, 86th, 87th, 88th, 89th, 90th, 91st, 92nd, 93rd, 94th, 95th, 96th, 97th, 98th, 99th, 100th

AFI, Yongsan Area

AFE, 2D Inf Div

AFE, Area II Spt Unit

AFE, Cp Humphreys

AFE, Pusan

AFE, Taegu

DLA ATTN: DLA-WI

USA Japan (USARJ), Ch. FE Div, AEEN-FE

Fac Engr (Honshu)

Fac Engr (Okinawa)

RDK/US Combined Forces Command, ATTN: EUSA-MHC-CFC-Engr

416th Engineer Command, ATTN: Facilities Engineering

Norton AFB, ATTN: AFRC-EX, DEE

Port Hueneme, CA 91043, ATTN: Library (Code LORA)

AFESC/Engineering & Service Lab, Tyndall AFB, FL 32403

Chanute AFB, IL 6186P, 2345 CES/DE, Stop 27

National Guard Bureau, Installation Division, WASH DC 20310

FSM Team Distribution

Director of Facilities Engineering
ATTN: AFZ1-FE-E
Ft. Richardson, AK 99505

Ft. Clayton, Canal Zone 34004
ATTN: OFAE

USA Liaison Detachment
ATTN: Library
APO New York 10007

West Point, NY 10996
ATTN: Dept of Mechanics
ATTN: Library

HQDA (SGRD-EDE)

Chief of Engineers
ATTN: DAEN-WPE-C
ATTN: DAEN-MPZ-A
ATTN: DAEN-ZCP

National Defense Headquarters
Director General of Construction
Ottawa, Ontario, Canada K1A 0K2

Division of Bldg Research
National Research Council
Ottawa, Ontario, Canada K1A 0R6

Airports and Const Services Dir
Technical Info Reference Centre
Ottawa, Ontario, Canada, K1A 0N8

Ft. Belvoir, VA 22060
ATTN: Learning Resources Center
ATTN: ATSE-TD-TL (2)
ATTN: Canadian Liaison Officer (2)
ATTN: British Liaison Officer (5)

Ft. Leavenworth, KS 66027
ATTN: ATZLCA-SA

Ft. Monroe, VA 23651
ATTN: ATEN-AD (3)
ATTN: ATEN-C
ATTN: ATEN-RAG
ATTN: ATEN-RM
ATTN: ATEN-C-C/D. Lyon

Ft. Lee, VA 23801
ATTN: DRXMC-D (2)
ATTN: DALO-TDA-T

Ft. McPherson, GA 30330
ATTN: AFEN-CD

US Army Foreign Science & Tech Center
ATTN: Charlottesville, VA 22901
ATTN: Far East Office

6th US Army
ATTN: AFKC-EN

7th US Army
ATTN: AETTM-HRD-EHD

HQ, Combined Field Army (ROK/US)
ATTN: CFAR-EN

US Army Engineer District
New York
ATTN: Chief, NANEN-M
ATTN: Chief, Design Br
Pittsburgh
ATTN: Chief, ORPCD
ATTN: Chief, Engr Div

US Army Engineer District
Philadelphia
ATTN: Chief, NAPEN-D
Norfolk
ATTN: Chief, NAOEN-M
ATTN: Chief, NAOEN
Huntington
ATTN: Chief, ORHED
Wilmington
ATTN: Chief, SAWCO-C
ATTN: Chief, SAWEN-D
Charleston
ATTN: Chief, Engr Div
Savannah
ATTN: Chief, SASAS-L
Jacksonville
ATTN: Const Div
Mobile
ATTN: Chief, SAMEN
Memphis
ATTN: Chief, Const Div
Vicksburg
ATTN: Chief, Engr Div
Louisville
ATTN: Chief, Engr Div
Detroit
ATTN: Chief, NCEED-T
St. Paul
ATTN: Chief, ED-E
ATTN: Chief, CO-C
Chicago
ATTN: Chief, NCCCO-C
Rock Island
ATTN: Chief, Engr Div
ATTN: Chief, NCRED-D
St. Louis
ATTN: Chief, ED-D
Kansas City
ATTN: Chief, Engr Div
Omaha
ATTN: Chief, Engr Div
New Orleans
ATTN: Chief, LMNED-DG
Little Rock
ATTN: Chief, Engr Div
Fort Worth
ATTN: Chief, SWFED-D
ATTN: Chief, SWFED-F
Galveston
ATTN: Chief, SWGCC-C
Albuquerque
ATTN: Chief, Engr Div
San Francisco
ATTN: Chief, Engr Div
Sacramento
ATTN: Chief, SPKED-D
ATTN: Chief, SPKCO-C
Far East
ATTN: Chief, Engr Div
Walla Walla
ATTN: Chief, Engr Div
Alaska
ATTN: Chief, NPASA-R
Seattle
ATTN: Chief, NPSCO
ATTN: Chief, EN-DB

US Army Engineer Division
New England
ATTN: Chief, NEDED-E
ATTN: Chief, NEDED-T
North Atlantic
ATTN: Chief, NADEN
ATTN: Chief, NADEN-T
Middle East, Rear
ATTN: Chief, MEDED-T
South Atlantic
ATTN: Chief, SADCO
ATTN: Chief, SADEN-TS
ATTN: Chief, Laboratory

Huntsville
ATTN: Chief, HNDED-CS
ATTN: Chief, HNDED-M
ATTN: Chief, HNDED-ME

US Army Engineer Division
Ohio River
ATTN: Chief, Engr Div
ATTN: Chief, Laboratory
North Central
ATTN: Chief, Engr Div
Missouri River
ATTN: Chief, MRDED-M
ATTN: Chief, Engr Div
Southwestern
ATTN: Chief, SEDED-MA
ATTN: Chief, SWOCO-CA
Pacific Ocean
ATTN: Chief, Engr Div
ATTN: Chief, PODED-M
ATTN: FM&S Branch
North Pacific
ATTN: Chief, Engr Div

AF/RDXT
WASH DC 20330

Tinker AFB, OK 73145
2854 ABG/DEEE

Patrick AFB, FL 32925
ATTN: 4RQ

AF/PREEU
Bolling AFB, DC 20332

AFESC/PRT
Tyndall AFB, FL 32403

Little Rock AFB
ATTN: 314/DEEE

AFWL/DEO
Kirtland AFB, NM 87117

Naval Training Equipment Center
ATTN: Technical Library
Orlando, FL 32813

NAVFAC/Code 04
Alexandria, VA 22332

Port Hueneme, CA 93043
ATTN: Morell Library

Washington, DC
ATTN: Building Research Advisory Board
ATTN: Transportation Research Board
ATTN: Federal Aviation Administration
ATTN: Dept of Transportation Library
ATTN: Dept of Energy

DeLong, Carl E

Expected use of micro-based network analysis / by Carl E. DeLong,
Janet H. Spoonamore. -- Champaign, IL : Construction Engineering
Research Laboratory ; available from NTIS, 1981.
15 p. (Technical Manuscript ; P-122)

Reprint of a paper presented at the First International Computer
Conference in Civil Engineering, New York, May 1981.

I. U.S. Army - Military Construction operations - data processing.
2. Microcomputers. 3. Network analysis (planning). I. Spoonamore,
Janet H. II. Title. III. Series: U. S. Army. Construction Engi-
neering Research Laboratory. Technical Manuscript ; P-19.